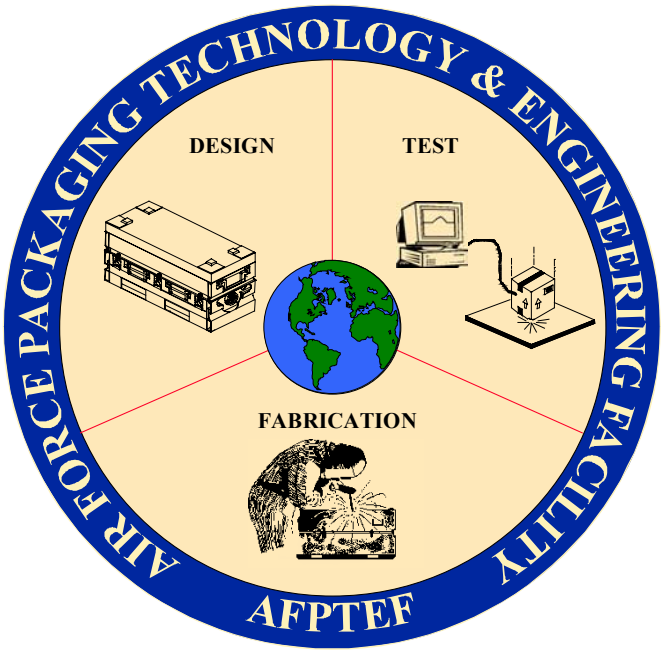

AFMC LSO/LOP
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PACKAGING PERFORMANCE TESTING OF A CORRUGATED FIBERBOARD BOX (14 IN. BY 14 IN. BY 12 IN.), CONTAINING ONE LEAD-ACID BATTERY – PACKING GROUP II

Date: June 18, 2002

AFPTEF PROJECT NUMBER: 02-P-105
POP TEST ID NUMBER: DODPOPHM/USA/DOD/AF69/DLA-F059

Part 1.

A. Title: PACKAGING PERFORMANCE TESTING OF A CORRUGATED FIBERBOARD BOX (14 IN. BY 14 IN. BY 12 IN.), CONTAINING ONE LEAD-ACID BATTERY – PACKING GROUP II

Report Number: DLA-059
AFPTEF Project Number: 02-P-105
Manhours: 40

Report Type: **FINAL**

B.
TEST REPORT APPLICABILITY STATEMENTS see section 2E.

Report Prepared by:

SIGNED
SUSAN J. EVANS
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Approved by:

SIGNED
MICHAEL WERNEKE
Reviewer

SIGNED
ROBBIN L. MILLER
Chief, AF Packaging Technology and Engineering

Testing Completion Date: 7 June 02

Approved for Publication and Dated: 18 Jun 02

Responsible Individual: Robbin L. Miller

Performing Activity: AF Packaging Technology and Engineering Facility
AFMC LSO/LOP
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Specific Authority: Distribution Statement F. Further dissemination only as directed by AFMC LSO/LOP or higher DoD authority.

Requesting Organization: Defense Distribution Center
DDC-J-3/J-4-0
ATTN: POP Team
2001 Mission Drive
New Cumberland PA 17070

Requesting Organization's Reference(s):
(1) Letter 01 May 2002

Part 2. Data Sheet

A. Exterior Shipping Container

UN Type: Fiberboard box
UN Code: 4G
NSN: 8115-00-183-9489
Specification Number(s): ASTM D5118, Style RSC, ASTM D4727, Type CF, Class WR, Var SW, Gr 400, V3c
Container Manufacturer: Lynchburg Sheltered Industries, Lynchburg, VA 24501
Date of Manufacture: 2002 (GSA advice code "2G" – newest stock)
Material: Corrugated Fiberboard
Container Dimensions: 14 in. x 14 in. x 12 in. ID
Closure (Type/Method): ASTM D1974, Sealing Method B (7-Strip Method). Use 2-inch A-A- 1830 clear tape on closure, NSN 7510-00-266-6715.
Reinforcement (Type/Method): ASTM D1972, Reinforcement Method 2B, using 1-inch wide filament reinforced tape (1 girthwise band for every 15 inches of box height/length).
Closure Specification Number(s): A-A-1830 clear tape, 2-inch, NSN 7510-00-266-6715.
Reinforcement Specification Number(s): A-A-1687 Fiber Reinforced Tape, 1-inch; NSN 7510-00-582-4772.
Absorbent Material Description: Vermiculite, Fine Grain, Palmetto Vermiculite Company, Incorporated, Grade C-3.
Additional Description: N/R

B. Inner Packaging of Tested Item (see photos, Figures 1 – 7, and drawing).

1. Place one battery in 4-mil polyethylene bag (gusseted or non-gussetted) with a minimum depth of 32 in. and sufficient width and breadth to loosely accommodate the battery. Smooth bag up the sides of the battery, pressing out air, and wrap a strip of tape (any kind) around the horizontal girth of the bag/battery to hold the bag as closely to the battery as possible. Gather bag at top of battery, continuing to press as much air as possible out of the bag, and twist tightly at the top surface of the battery. Bind the twist with an 8-in. minimum strip of reinforced tape. Fan out loose top of bag, smooth sides together pressing out as much air as possible; roll/fold tightly down to the top of the battery; tape rolled bag down over the top length of the bagged battery using a 2-in. wide strip of clear sealing tape, to form a smoothly sealed inner item (use as many strips of any length as required to achieve a smooth seal). The rolled top should be as compressed as possible to permit the greatest depth of vermiculite on the top surface. This strip of rolled bag will also provide additional cushioning for the battery top and/or terminals.

2. Line the box with a 4-mil gussetted polyethylene bag, size 16 in. x 14 in. x 36 in., minimum.

3. Place 2 inches of vermiculite absorbent in bottom of box and compress, adding more vermiculite as needed to maintain a depth of 2 inches. Place the sealed battery on top of the vermiculite, centering it between the four box sides. Add vermiculite between the battery and sides of box, and either shake packaging or compress, adding more vermiculite until all spaces are tightly packed with vermiculite. Cover with a minimum of 2 in. vermiculite, compress and add vermiculite as needed to create a tight pack that will tightly fill the internal height of box when closed. **NOTE: Although there is not a full two inches of absorbent material on the top and bottom, based on total amount of absorbent, the OPR listed in AFJMAN 24-204, Atch. 20 has approved this configuration.**

4. Twist box liner closed and tape the twist with an 8-inch minimum strip of fiber reinforced tape.

5. Closure IAW 2a.

C. Actual Product: Not Used

Name: Lead-acid Automotive Battery
NSN: N/A
Specification: Unknown
UN/DOT/IMO/IATA Proper Shipping Name: Battery, wet, filled with acid, electric storage (lead-acid automotive battery)
United Nations Code Number: UN 2794
United Nations Packing Group: III
UN Hazard Class: 8 **DOT Hazard Class:** 8
IMO Hazard Class: 8 **IATA Hazard Class:** 8

Physical State: SOLID
Items per container: 1
Gross Weight: 30.4 kg (67 lb)
Item Weight: 24.9 kg (55 lb)
Estimated Max. Volume of Internal Diluted Acid: 0.75 gallons (2.8 liters)
Density/Specific Gravity: N/A
Drop Height: 1.2 m (47.2 in.)
Stacking Weight/Force Required: 268.5 kg (592 lb)
Pressure Differential (vacuum): N/A
Vapor Pressure (liquids only) at 50/55°C: N/A
Consistency/Viscosity: N/A **Flash point:** N/A
Altitude: N/A
Minimum Cargo Compartment Pressure: N/A
Additional Description: NA**.**

D. Test Product: Used
Name: Sealed battery, filled with acid/gel, (automotive battery with other characteristics as above)
United Nations Packaging Group: III
Physical State: Solid
Items per outer container: 1
Gross Weight (packaged with vermiculite): 30.4 kg (67 lb) See Part 3.
Test Item Weight: 24.9 kg (55 lb)
Test Item Dimensions: 254.0 mm x 177.8 mm x 203.2 mm **(**10 in. x 7 in. x 8 in.)
Estimated Max. Volume of Internal Diluted Acid: 0.75 gallons (2.8 liters)
Density/Specific Gravity: NA
Drop Height: 1.2 meters (47.2 in.)
Stacking Weight/Force Used: 272.2 kg (605 lb)
Additional Description: N/A

E. Test Applicability- See test results in parts 7

(1) Tests documented herein are design qualification. It is the responsibility of the government shipper/certifier to fully verify design compliance and packaging material quality.

(2) Drop testing performed herein was tested in accordance with DLAD 4145.41, AR 700-143, AFJI 24-210, NAVSUPINST 4030.55A, and MCO 4030.40A. This joint DoD policy document allows packaging to be drop tested more than once provided the packaging continues to pass the 49CFR 178.603 requirements. Questions about or clarification of this policy can be sought from the respective preparing activities of the regulation.

(3) DoD contractor use of this test report or its resultant certifying mark only with the permission of the testing activity AND as specified in DLAD 4145.41, AR 700-143, AFJI 24-210, NAVSUPINST 4030.55A, and MCO 4030.40A.

(4) Pass/fail conclusions were based on the particular specimens, both inner and outer containers, and quantities of each submitted for test. Extrapolation to other manufacturers, applications, commodities, inner containers, container sizes, or lesser internal quantities is the responsibility of the packaging design agency or applicable higher headquarters and the limitations documented in 49CFR. Extrapolation of test results based on lesser than minimum UN/DOT required test specimens is also the responsibility of the packaging design agency or applicable higher headquarters.

(5) Reference to specification materials has been made based on one of the following methods: supplied by AFPTEF, provided by the requester, markings printed on, attached to or embossed on the packaging.

(6) Testing performed in accordance with 49CFR 170-180, except as documented in this report.

(7) Performance testing was undertaken and completed at the request of an agency responsible for management of the dangerous good(s). The completion of successful UN/DOT testing does not, by itself, authorize the marking and transportation of the dangerous good(s). Applicable modal regulations should be consulted concerning the relationship of performance testing completed and the dangerous good(s).

(8) The DOT performance tests are intended to evaluate the performance of the entire packaging configuration's ability to prevent the release of contents during conditions normally incident to transportation. The criteria used to evaluate container system performance is whether the contents of the packaging are retained intact. The successful completion of the recommended tests does not ensure undamaged delivery.

(9) Tests performed and documented, herein, in no way verify Government supplier's operations (included but not limited to: internal procedures, suppliers, or manufacturing processes) comply with the DOT's or international's regulations. The testing facility has no knowledge and assumes no knowledge, that specific material testing requirements (i.e. plastics - only allowed to use regrind from the same operation; specific vendor plastic formulations including quantity of carbon black, ultra-violet inhibitors or pigments, or production run's individual leakproofness tests) are or were performed by the manufacturer(s) listed herein, unless otherwise noted in the report.

Part 3. Introduction.

Brief description of why specific tests were performed and rationale for the test product selected (if applicable).

The equivalent of Packing Group II testing was requested on the above stated configuration. For lesser volumes, variations to testing requirements can be found in 49 CFR, part 178.601(g).

A gel-acid battery was used as the test item as permitted by 49 CFR part 178.602(c).

Each packaging was subjected to appropriate drop and vibration testing as prescribed by ASTM D4919. These tests are designed to simulate the shock and vibration a package configuration may encounter during conditions normally incident to transportation. The order of testing was drop test followed by the vibration test; the stacking test was performed on an empty outer container. The Cobb test was performed on samples taken from boxes not otherwise used in testing.

The use of one sample packaging configuration for multiple tests and drops is DoD policy as stated in DLAD 4145.41, AR 700-143, AFJI 24-210, NAVSUPINST 4030.55A, and MCO 4030.40A. This option was exercised in this test as noted in Part 6.

Part 4. Tests Required/Performed (as applicable).
NOTE: Packagings fabricated from fiberboard, paperboard, or paper, including composite containers with outer fiberboard containers, should be conditioned for a minimum 24 hours prior to any testing. Standard conditions **23 ± 3°C (73 ± 4°F)** and **50 ± 2%** relative humidity apply.

A. Hydrostatic Pressure Test. 3 outer containers each individually tested for 5 minutes at 15 psig. **Not applicable.**

B. Stacking Test. One test per outer container, 3 containers required. Compression by a top load is calculated to simulate a stack height of **3 meters**, maintained for 24 hours. **NOTE:** If only one configuration sample is tested, test duration shall be 72 hours.

Static weight. Apply the calculated weights using a constant load evenly over the entire container.

$$M = \frac{m\,(3000-h)}{h}$$

where: m = container's gross mass (as shipped) in kilograms = 30.39 kg
h = container's height in millimeters = 304.8 mm (effective height for container in stack)
M = constant load mass in kilograms = 268.72 kg

or:
$$W = \frac{w\,(118-h)}{h}$$

where: w = container's gross weight (as shipped) in pounds = **67 lb**
h = container's height in inches = **12 in.** (effective height for container in stack)
W = constant load weight in pounds = **591.83 lb**

NOTE: Where the contents of the test sample are non-dangerous liquids with relative density different from that of the liquid to be transported, the force shall be calculated in relation to the latter.

Information - This test assumes similar weight containers stacked on top of the test sample. This may or may not be a valid assumption. This calculation also only provides a minimum weight. Consideration should be given to what will actually be experienced in the transportation cycle.

C. Drop Test. 5 drops in order: flat on the top, bottom, long side, short side and top corner. The drop height shall be appropriate for the packaging group of the commodity. The container shall strike a target which shall be a rigid, non-resilient, flat, and horizontal surface. For other than flat drops, the center of gravity shall be vertically over the point of impact.

1. Solids and liquids, if the test is performed with the actual contents to be carried, or with another substance having essentially the same characteristics, or for liquids if the test is performed with water and the intended contents has density less than 1.2 g/cm^3 (specific gravity less than 1.2) the drop height shall be:

Packing Group	Drop Height
I	**1.8m** (70.9 in.)
II	**1.2m** (47.2 in.)
III	**0.8m** (31.5 in.)

2. Where the test sample doesn't contain the intended contents and its specific gravity is greater than 1.2, then obtain the required drop height in meters by calculating the following with product density (d):

Packing Group	Drop Height
I	**(d) x 1.5m** ((d) x 59.1 in.)
II	**(d) x 1.0m** ((d) x 39.4 in.)
III	**(d) x 0.67m** ((d) x 26.4 in.)

Round the drop height up to the first decimal.

D. Vibration Test (domestic requirement). One test per container, total of three test specimens.

The test shall be performed for 1 hour at a frequency that causes the package to be raised from the vibrating platform to such a degree that a piece of material approximately **0.2 cm** (1/16 in.) thickness can be passed between the bottom of the package and the platform. The vibrating platform shall have a vertical double-amplitude (peak-to-peak) displacement of **2.54 cm** (1 in.). Perform tests in accordance to 49CFR 173 Subpart B, Appendix C and 49 CFR 178. **NOTE: If only one configuration sample is tested, test duration shall be 3 hours.**

MATERIAL SPECIFIC TEST

E. Fiberboard Water Resistance (Cobb) Test. One test per fiberboard specimen, total of six.
Strong, solid or double faced corrugated fiberboard (single or multi-walled) must be used, appropriate for the capacity and the intended use of the box. The water resistant outer surface must not increase in mass greater than **155 grams per meter^2 (0.0316 pounds per foot^2)** after 30 minutes in accordance with International Standards Organization (ISO) 535 or Technical Association of the Pulp and Paper Industry (TAPPI) T441 or ASTM D 3285. Three individual fiberboard specimens shall be exposed on the wire side and another three on the felt side.

Part 5. Criteria for Passing Tests.

A. Hydrostatic Pressure Test. Any leakage is cause for rejection. **Not applicable.**

B. Stacking Test.
No test sample shall leak. Composite and combination containers shall not exhibit leakage of the filling substance from the inner receptacle or container. No test sample shall show deterioration which adversely affects transportation safety or show any distortion liable to reduce its strength, cause stacking instability, or cause damage to internal container components likely to reduce transportation safety.

C. Drop Test.
Each packaging containing liquids shall be leakproof when internal and external pressures are equalized. Composite and combination containers shall not exhibit damage to the outer packaging likely to adversely affect transportation. In addition, the inner packaging shall not leak into the filling substance or lading.

D. Vibration Test.
No rupture or leakage from any of the packages. No test specimen shall show any deterioration which could adversely affect transportation safety, result in possible discharge of contents or reduce packaging strength.

E. Fiberboard Water Resistance Test.
The calculated water absorption of all samples shall be less than **155 g/m^2.**

Part 6. Discussion and Test results.
Narrative description of test results, including any rationale for variations. For each packaging to pass, all applicable tests must be performed and pass criteria listed herein.

A. Hydrostatic Pressure Test. Not applicable.

B. Drop Test. Pass

Tested at standard conditions: 23 Degrees C., 50% RH.
The packaging was dropped 1.2 meters onto the required four flat sides and a bottom corner (equivalent to a top corner). There was no leakage from the battery. There was no damage to the battery that would be likely to cause leakage or damage to the packaging during transportation. There was no damage to the outer container that would be likely to cause leakage from, or weakening of, the package during transportation. See Figure 8.

C. Stacking Test. Pass

Duration: 24 hours at standard conditions: 23 Degrees C., 50% RH.
One empty closed outer container was stacked with 600 lb for 72 hours. There was no damage to the box which could result in damage to the inner item, no crushing, nor stack instability. No other adverse results were noted. See Figure 9.

D. Vibration Test. Pass

Duration: 3 hours at standard conditions: 23 Degrees C., 50% RH.
The same packaging used in the drop tests was also used for the vibration test. The packaging was tested on an electro-hydraulic vibration table which was set at 1-inch vertical double amplitude (peak-to-peak) displacement, at a frequency such that the packaging was raised from the platform. The distance was measured using a 1/16-inch feeler gage. At the proper frequency the feeler gage could be passed between the bottom of the package and the table surface. There was no additional damage to the outer container caused by the vibration and no leakage from the battery. This test procedure duration of 3 hours with one container exceeds the 49 CFR requirements. See Figure 10.

E. Water Resistance (Cobb) Test. Pass

Test at standard conditions: 23 Degrees C., 50% RH.
As required by 49 CFR part 178.516, ASTM D 3285 Water Absorptiveness of Nonbibulous Paper and Paperboard (Cobb Test) was performed on specimens cut from the lot of boxes used in the drop stack and vibration tests. The test period (exposure of the samples to water) was 30 minutes.

3 Specimens were tested on the exterior side. Average **124.48 g/m^2.**
Values : **117.8 g/m^2, 119.15 g/m^2, 129.78 g/m^2, 124.37 g/m^2, 123.31 g/m^2**
3 Specimens were tested on the interior side. Average **123.24 g/m^2.**
Values : **90.73 g/m^2, 131.76 g/m^2, 124.83 g/m^2, 153.95 g/m^2, 114.95 g/m^2**

0 Specimens exceeded the 155 grams per square meter maximum limit.

Many factors may affect water absorption by corrugated fiberboard. Among these factors are abrasion, wear, flexure, improper storage, and age. These can greatly decrease the ability of the fiberboard to resist water absorption and result in higher than tested results. In addition, some fiberboard products are only treated on one side of the material, making the box construction method of increased importance. Usually, the water resistant side is the smooth side. The shipper must take appropriate steps to ensure that the box is correctly constructed with the water resistant side on the outside.

Part 7. Performance Marking on Container:

The container specified herein passes the DoT and international regulatory requirements to the extent tested. Equivalent DoD built or grandfathered containers MAY also qualify for the following marking as directed by DoD policy documents.

Part 8. References

A. 49CFR 170-180
B. DLAD 4145.41/AR 700-143/AFJI 24-210/NAVSUPINST 4030.55A/MCO 4030.40A - Packaging of Hazardous Materials
C. ISO 535/TAPPI T 441/ASTM 3285 - Determination of Water Absorption of Paper and Board (Cobb Method)
D. ISO 3574 - Cold-reduced carbon steel sheet of commercial and drawing quantities.
E. ASTM D999 - Methods for Vibration Testing of Shipping Containers.

Part 9. Distribution List

Commander
Defense Logistics Agency
DDC-J-3/J-4-0
ATTN: Linda McCarthy
2001 Mission Drive
New Cumberland PA 17070

AFMC LSO/LOP
Project Folder

Figure 1. Battery in bag, with tape band around horizontal circumference. Tape band holds bag against battery, keeping excess air out of bag and making it easier to close bag.

Figure 2. Battery in closed bag. Top is twisted shut and twist is bound with strip of fiber-reinforced packaging tape.

Figure 3. Battery in closed bag. Top of bag enclosing battery is twisted and taped shut, then rolled down along the top length of the battery, and taped down across the length of the battery using the 2-inch wide packaging tape

Figure 4. Battery in closed bag, centered in outer packaging with vermiculite packed around all 4 sides.

Figure 5. Battery in bag, almost completely surrounded by vermiculite. Approximately 2 inches of vermiculite will be added and compressed on top of battery before closing box liner.

Figure 6. Closed inner liner of package containing one battery.

Figure 7. Closed packaging. Note vertical and horizontal girthwise strip of fiber-reinforced packaging tape.

Figure 8. Minor crushing of packaging corner caused by drop test.

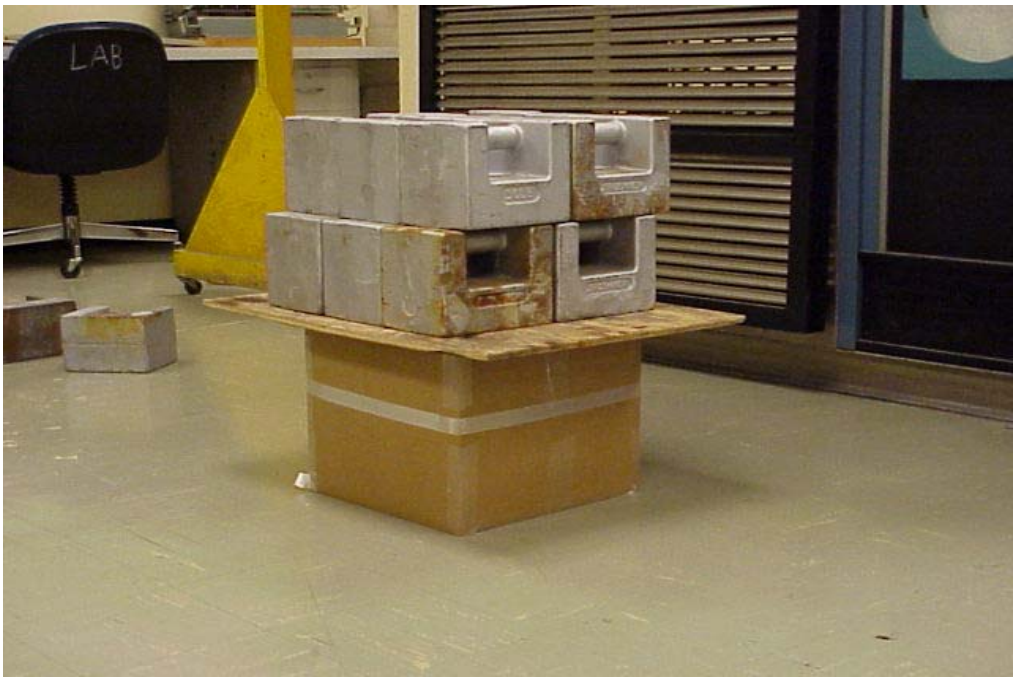
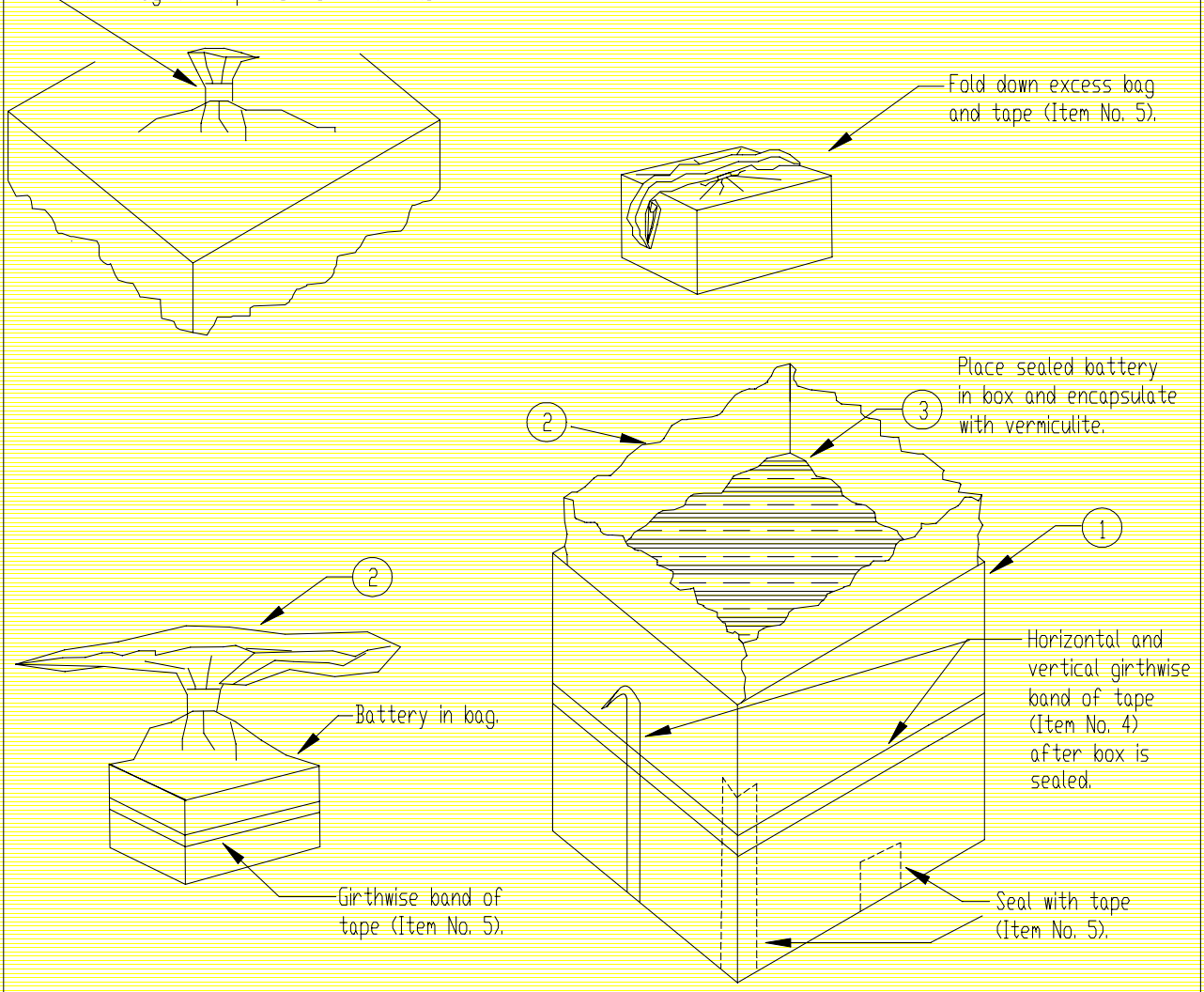


Figure 9. Stack test.

Figure 10. Vibration test.



Item	Qty	Description	Notes
5	A/R	Clear Sealing Tape, 2-inch width	NSN 7510-00-266-6715
4	A/R	Fiber Reinforced Tape, 1-inch width	NSN 7510-00-582-4772
3	A/R	Absorbent Vermiculite	
2	2	4-mil Poly Bag	
1	1	SW Corr. Fiberboard Box, 14 in. x 14 in. x 12 in.	NSN 8115-00-183-9489

File: DLAF059-02.DWG	AFPTEF Air Force Packaging Technology and Engineering Facility	Note: Follow All Instructions in TR
Dwg No: DLAF05902		Dimensions in Inches
Engineer: Evans/Sessions	DATE: 17 June 02	Scale: NONE
		PAGE 1 OF 1